Intertemporal Substitution in the Time Allocation of Married Women*

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Abstract

This paper studies a life-cycle model of home production to examine how married women change their allocation of time in response to evolutionary movements along the life-cycle wage profile in Japan. After accounting for the potential bias due to heterogeneity, measurement error, weak instruments, and missing data, the estimates of intertemporal substitution elasticity obtained from the home production model are moderate and similar to those obtained from the standard labor supply model.

Keywords: labor supply, home production, intertemporal substitution

JEL Classification: J22

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1 Introduction

We devote a great deal of time to work for wages, but in fact spend more time outside the market. Non-market activities comprise home production and leisure, which differently influence economic welfare. Given that time engaged in home production is comparable to time involved in market work for young and middle-aged married women, the number of hours of leisure, which is a major determinant of welfare, varies significantly depending on whether home production is distinguished from leisure. Recognizing that a considerable amount of time is spent in home production, the relevant parameter for conducting welfare analysis is not a preference parameter in the standard labor supply model that concerns substitution between market work and the rest of one's time, but a preference parameter in the home production model that governs intertemporal substitution between leisure and total work, including market work and home production.

The argument that the estimates of labor supply elasticity can change after taking home production into account began with Mincer (1965). While Becker (1965) established the theory of time allocation, and Gronau (1977) improved the empirical tractability of the model, Lucas and Rapping (1969), Ghez and Becker (1975), Heckman and MaCurdy (1980), and MaCurdy (1981) developed a life-cycle model of labor supply. There was no empirical research regarding intertemporal substitution based on the home production model until Rupert, Rogerson, and Wright (1995, 2000). Rupert, Rogerson, and Wright (2000) provided a transparent analytical framework, in which the preference parameters of interest differ based on the underlying economic model, and argued that the estimates of intertemporal substitution elasticity obtained from the home production model are significantly greater than those obtained from the labor supply model. The argument seems to be appealing as a way to reconcile micro and macro labor supply elasticities, as referred to by Chang and Hornstein (2008). Nonetheless, there has not yet been much compelling empirical evidence on this issue, considering that the Rupert, Rogerson, and Wright (2000) study draws its conclusion from the results of ordinary least squares and weighted least squares regressions with few controls using cohort data for males in the United States. The use of controls and instruments is crucially important for economic interpretation of estimated parameters in this context, because evolutionary movements along the life-cycle wage profile are required to identify the elasticity of intertemporal substitution, as reviewed by MaCurdy (1985) and Blundell and MaCurdy (1999).

This study deals with several econometric issues that arise in estimating the elasticity of intertemporal substitution. The problems faced when estimating the home production model are essentially the same as the problems faced when estimating the labor supply model. The estimates of intertemporal substitution elasticity can be biased due to preference heterogeneity, measurement error, weak instruments, and missing data. Between the two models, however, the direction and size of the bias due to heterogeneity such as demographics are expected to differ, and the direction of bias due to measurement error can be shown to be opposite. The weak instrument problem is considered to be a cause of typically small and imprecise estimates of intertemporal substitution elasticity. This study uses Japanese time-use data for estimation, and the focus of the analysis is on married women who bear a central role in home production and change the allocation of time over the life cycle, especially in Japan. After exploiting variation in wages over the life cycle conditional on a set of relevant controls and accounting for the potential bias arising from several econometric problems, the estimates of intertemporal elasticity obtained from the home production model are moderate and similar to those obtained from the standard labor supply model. These results can be interpreted along the lines of previous studies that estimate the life cycle of labor supply and the static model of time allocation in other advanced industrialized nations.

The paper proceeds as follows. The next section develops a life cycle model of home production with uncertainty and heterogeneity and derives an estimable Frisch demand function. Section 3 presents an econometric framework to estimate the elasticity of intertemporal substitution and discusses econometric issues regarding measurement error, weak instruments, and missing data. Section 4 describes data used in the analysis and performs preliminary analysis to examine comparability with previous studies that conduct cross-sectional regressions of disaggregated hours. Section 5 presents the main results and provides the interpretation of the estimates of intertemporal substitution elasticities in both the labor supply model and the home production model. The final section concludes.

2 Conceptual Framework

The life-cycle model considered here is an extension of the static home production model developed by Gronau (1977) and Sandmo (1990). In this model, the household derives utility from the consumption of market-produced goods (c_m), the consumption of home-produced goods (C_n), and leisure (h_l). The marginal utility varies with preference shifters (s) such as demographics. The household is endowed with asset (a), and the husband and wife, respectively, are endowed with time ($\overline{h}$) that is allocated to market work (h_m), home production (h_n), and leisure. They can earn wages of w per hour of work in the market. Home goods are produced from intermediate goods (q) purchased in the market at price (p) and time engaged in home production according to the home production technology $f(\cdot)$. Let $\mathbb{E}_t$ denote the expectation operator conditional on an information set in period t. The tilde $\sim$ is put on the variables for the husband. The intertemporal optimization problem faced by the household is to maximize the expected value of the discounted sum of total utility:

$$\mathbb{E}_\tau \sum_{t=\tau}^{T} (1+\rho)^{\tau - t} \left[U\left(c_{mt}, C_{nt}, h_{lt}; s_t\right) + \widetilde{U}\left(\widetilde{c}_{mt}, C_{nt}, \widetilde{h}_{lt}; s_t\right)\right] \tag{1}$$

subject to

$$\begin{aligned}
h_{mt} + h_{nt} + h_{lt} &= \overline{h}, && (2a)\\
\widetilde{h}_{mt} + \widetilde{h}_{nt} + \widetilde{h}_{lt} &= \overline{h}, && (2b)\\
c_{mt} + \widetilde{c}_{mt} + p_t q_t + a_{t+1} &= w_t h_{mt} + \widetilde{w}_t \widetilde{h}_{mt} + (1+r_t)\, a_t, && (2c)\\
C_{nt} &= f\left(q_t, h_{nt}, \widetilde{h}_{nt}\right), && (2d)
\end{aligned}$$

where ρ is the rate of time preference, and r is the real rate of return on assets. Combining the constraints (2a), (2b), and (2c), the period-by-period budget constraint can be written as $c_{mt} + \widetilde{c}_{mt} + w_t\left(h_{nt} + h_{lt}\right) + \widetilde{w}_t\left(\widetilde{h}_{nt} + \widetilde{h}_{lt}\right) + p_t q_t + a_{t+1} = w_t \overline{h} + \widetilde{w}_t \overline{h} + (1+r_t)\, a_t$.

A dynamic programming formulation provides a convenient framework for characterizing the optimal decisions on consumption and hours. Define $V(a_t, S_t)$ as the optimum value of the consumption-leisure choice problem given information up to period t, where S includes all relevant state variables. The value function obeys the Bellman equation:

$$V\left(a_t, s_t\right) = \max \left[\begin{array}{c} U\left(c_{mt}, f\left(q_t, h_{nt}, \widetilde{h}_{nt}\right), h_{lt}; s_t\right) + \widetilde{U}\left(\widetilde{c}_{mt}, f\left(q_t, h_{nt}, \widetilde{h}_{nt}\right), \widetilde{h}_{lt}; s_t\right) \\ +\frac{1}{1+\rho}\mathbb{E}_t V\left(a_{t+1}; S_{t+1}\right) \end{array} \right]. \quad (3)$$

The optimal solution can be characterized by first-order conditions for consumption c_m, $\widetilde{c}_m$, and q and hours h_l, $\widetilde{h}_l$, h_n, and $\widetilde{h}_n$, together with an intertemporal optimality condition for the marginal utility of wealth in period t. Assuming that preferences are additively separable between consumption and leisure in a similar fashion to Ruppert, Rogerson, and Wright (2000), such that $U\left(c_{mt}, C_{nt}, h_{lt}; s_t\right) = u\left(c_{mt}, C_{nt}; x_t\right) + v\left(h_{lt}; s_t\right)$, the first-order condition with respect to h_l and the intertemporal optimality condition are

$$v_{h_l} = \lambda_t w_t, \quad (4a)$$

$$\lambda_t = \frac{1 + r_{t+1}}{1+\rho}\mathbb{E}_t \lambda_{t+1}, \quad (4b)$$

where λ is the Lagrange multiplier associated with the budget constraint. Following Browning and Meghir's (1991) conditional demand approach, the vector of preference shifters s can include an endogenous variable, and in that case preferences are expressed as conditional on the optimal value of such a variable. The fertility decision is abstracted from the optimization problem above but is taken into account by incorporating the number of children as a determinant of marginal utility of consumption and leisure. An interior solution is assumed to exist, i.e., $0 < h_l < \overline{h}$, but this assumption is innocuous because every individual in the data spends some time on market work or home production. Therefore, no distinction is made between extensive and intensive margins.

Assuming that preferences exhibit constant absolute risk aversion such that $v\left(h_{lt}; s_t\right) = \alpha_l \exp\left(h_{lt}/\alpha_l\right) \cdot \exp\left(-\left(x_{vt}\delta_l + \epsilon^l_{vt}\right)/\alpha_l\right)$, where $\alpha_l < 0$, and the preference shifters s are divided into observed characteristics x_v, such as education and children, and a stochastic preference shock ϵ_v, the first-order condition (4a) leads to the Frisch demand function:

$$h_{lt} = \alpha_l \ln \lambda_t + \alpha_l \ln w_t + x_{vt}\gamma_l + \epsilon^l_{vt}. \quad (5)$$

In effect, the demand equation (5) takes a familiar form except that the dependent variable is leisure excluding time engaged in home production. The functional form of preferences above is adapted because the semi-log model (5) is widely used in the literature on labor supply and is more directly comparable to the disaggregate analysis in section 4. If preferences exhibit constant relative risk aversion such that $v\left(h_{lt}; s_t\right) = 1/\left(1 + 1/\alpha_l\right) h_l^{1+1/\alpha_l} \cdot \exp\left(-\left(x_{vt}\delta_l + \epsilon_{vt}^l\right)/\alpha_l\right)$, the dependent variable is transformed to the log of hours. However, empirical results obtained are unchanged by the choice of the functional form of preferences.

Under uncertainty, the marginal utility of wealth can be written as $\ln \lambda_t = \mathbb{E}_{t-1} \ln \lambda_t + \epsilon_{\lambda t}$, where ϵ_λ is forecast error. The Euler equation (4b) can then be rearranged as
$\ln \lambda_t = b_t + \ln \lambda_{t-1} + \epsilon_{\lambda t}$, where $b_t = \ln\left[\left(1+\rho\right)/\left(1+r_t\right)\right] - \ln\left[\mathbb{E}_{t-1} \exp\left(\epsilon_{\lambda t}\right)\right]$. The b term can be captured by a common macroeconomic effect if ϵ_λ is identically distributed across households. Repeated backward substitution yields

$$\ln \lambda_t = \sum\nolimits_{\tau=1}^{t} b_\tau + \ln \lambda_0 + \sum\nolimits_{\tau=1}^{t} \epsilon_{\lambda\tau}. \tag{6}$$

The first term is a common macroeconomic effect, the second term is a fixed effect, and the last term is the accumulated sum of forecast errors. The fixed effect can be differenced out when panel data are available, but first differencing aggravates the measurement error problem and the weak instrument problem. The analysis proceeds instead by specifying λ_0 and the life-cycle path of wages and property income in the same manner as MaCurdy (1981, 1985).

$$\ln \lambda_0 = f_\lambda + \sum\nolimits_{\tau=0}^{T} \psi_\tau \mathbb{E}_0 \ln w_\tau + \kappa a_0 + \epsilon_{\lambda 0}, \tag{7a}$$

$$\mathbb{E}_0 \ln w_t = \pi_{0k} + \pi_{1k} t + \pi_{2k} t^2 + \epsilon_{wt}, \tag{7b}$$

$$\mathbb{E}_0 y_t = \theta_{0k} + \theta_{1k} t + \theta_{2k} t^2 + \epsilon_{yt}, \tag{7c}$$

where f_λ is a vector of age-invariant characteristics observed in the initial period, y is property income, defined as $y_t = r_t a_{t-1}$, and $\epsilon_{\lambda 0}$, ϵ_w, and ϵ_y are the error terms. The life-cycle wage and income paths are known to be non-linear in age, and the intercept and slope parameters πs and θs vary by education group k.[1] This property of the wage profile provides variation in wages to

[1]The intercept and slope parameters in the life-cycle wage and income paths are described as invariant to charac-

identify the key parameter α_l. Recognizing that $a_0 = [(1+r_0)/r_0]\, y_0$, the Euler equation (6) can be expressed as

$$\ln \lambda_0 = f_\lambda + \phi_0 + \mu_0, \tag{8}$$

where $\phi_0 = \pi_{0k} \sum_{\tau=0}^{T} \psi_\tau + \pi_{1k} \sum_{\tau=0}^{T} \psi_\tau \tau + \pi_{2k} \sum_{\tau=0}^{T} \psi_\tau \tau^2 + [(1+r_0)/r_0]\, \kappa \theta_{0k}$ and $\mu_0 = \epsilon_{\lambda 0} + \sum_{\tau=0}^{T} \psi_\tau \epsilon_{w\tau} + [(1+r_0)/r_0]\, \kappa \epsilon_{y0}$. Here, the fixed effect is decomposed into the age-invariant characteristics, the combinations of parameters, and the approximation errors. The Frisch demand function can then be rewritten as

$$h_{lt} = \alpha_l \ln w_t + x_t \gamma_l + \epsilon_{lt}, \tag{9}$$

where $x_t \gamma_l = \alpha_l \phi_0 + \alpha_l f_\lambda + x_{vt} \delta_l + \alpha_l \sum_{\tau=1}^{t} b_\tau$ and $\epsilon_{lt} = \epsilon_{vt}^{l} + \alpha_l \mu_0 + \alpha_l \sum_{\tau=1}^{t} \epsilon_{\lambda\tau}$. The controls x include the constant, the initial household characteristics, preference shifters, and year effects, and the error term ϵ_l includes a preference shock, the approximation errors, and the accumulated sum of forecast error.

For comparison, consider the standard intertemporal optimization problem in which home production and leisure are lumped together as non-market activities (h_L). The household maximizes the expected value of the discounted sum of total utility:

$$\mathbb{E}_\tau \sum_{t=\tau}^{T} (1+\rho)^{\tau - t} \left[U\left(c_{mt}, h_{Lt}; s_t\right) + \widetilde{U}\left(\widetilde{c}_{mt}, \widetilde{h}_{Lt}; s_t\right)\right] \tag{10}$$

subject to

$$h_{mt} + h_{nt} + h_{lt} \;=\; \overline{h}, \tag{11a}$$

$$\widetilde{h}_{mt} + \widetilde{h}_{nt} + \widetilde{h}_{lt} \;=\; \overline{h}, \tag{11b}$$

$$c_{mt} + \widetilde{c}_{mt} + a_{t+1} \;=\; w_t h_{mt} + \widetilde{w}_t \widetilde{h}_{mt} + (1+r_t)\, a_t. \tag{11c}$$

This problem is restrictive in that home production is not endogenously determined. In this setting, leisure is the mirror image of market work. Under the same specifications as above, including

teristics other than education here for notational simplicity and for the source of identification to be transparent, but they can be allowed to vary with other observed characteristics.

$v(h_{Lt}; s_t) = \alpha_L \exp(h_{Lt}/\alpha_L) \cdot \exp\left(-\left(x_{vt}\delta_L + \epsilon_{vt}^L\right)/\alpha_L\right)$, the Frisch demand function can be derived as

$$h_{Lt} = \alpha_L \ln w_t + x_t\gamma_L + \epsilon_{Lt}, \tag{12}$$

where $x_t\gamma_L = \alpha_L\phi_0 + \alpha_L f_\lambda + x_{vt}\delta_L + \alpha_L \sum_{\tau=1}^{t} b_\tau$ and $\epsilon_{Lt} = \epsilon_{vt}^L + \alpha_L\mu_0 + \alpha_L \sum_{\tau=1}^{t} \epsilon_{\lambda\tau}$.

The derivation above shows that the Frisch demand function (12) in the labor supply model shares the same set of regressors and the same types of error terms with the Frisch demand equation (5) in the home production model. The only difference on the right-hand side is a preference shock, which is involved in the error term. From an econometric perspective, estimating the preference parameters requires dealing with similar econometric issues between the two models. From an economic perspective, the preference parameters have different economic meanings between the two models, and not α_L but α_l needs to be estimated for the welfare analysis taking home production into account.

3 Econometric Framework and Issues

3.1 Econometric Framework

On the basis of the theoretical analysis, the estimating equations can be parsimoniously described by

$$h_j = \alpha_j \ln w + X\Gamma_j + \epsilon_j \qquad \text{for} \quad j = l, L, \tag{13}$$

where X is a vector of controls that includes year dummies to control for macroeconomic effects, such as price changes over time, and preference shifters (x_v) and age-invariant characteristics (f_λ) to control for heterogeneity in preferences and the initial value of the marginal utility of wealth across households. More specifically, years of education, age, the number of children under the age of 7, and the number of children aged 7 to 17 are included as preference shifters; and family background characteristics, namely years of father's education, years of mother's education, number of siblings, and maternal age at birth (age difference with mother), are included as age-invariant characteristics. Paternal age is not included because it is highly collinear with maternal age. Regional dummies are also included to capture preference shifters, age-invariant characteristics, or a common regional effect. Japan can be divided into nine geographical regions, and all regional variables are created according to the region where one spent the longest period during compulsory education. The inverse Mills ratio is additionally included in X to circumvent the missing data problem. The specification leaves higher-order polynomials in age as instruments to exploit variation in wages (and fertility) over the life cycle. More specifically, the interaction terms between age squared and education dummies that account for anticipated wage changes along a given life-cycle wage path are used as instruments for the log hourly wage.

The number of young children is typically excluded from the hours equation when estimating the labor supply model and included only in the labor market participation equation as a variable that represents fixed costs of work. However, the number of children can shift preferences, and the hours of home production in fact vary with the number of young children significantly. Thus, this study considers two specifications: The first does not include the number of children in the hours equation, while the second does and treats it as endogenous. Cubic and quartic terms in age are used as instruments for the number of children under the age of 7 and the number of children aged 7 to 17.

Many survey data do not contain detailed information about time use. Because this makes it impossible to estimate preference parameters in the home production model, the existing estimates of Frisch elasticity are mostly not those of $-\alpha_l/h_l$, but rather $-\alpha_L/h_L$. The comparison between the two estimates should be useful to infer a potential error in the welfare implications of the standard labor supply model.

3.2 Measurement Error Problem

Measurement error in hours causes underestimation of wage effect on labor supply, which is known as the division bias (Hall, 1973; Borjas, 1980). The measurement error problem is severe in this context because the hourly wage is calculated by earnings divided by hours of work. Unlike the standard case of attenuation bias under the classical measurement error assumption, the division bias is not bounded by zero. Suppose that the reported hours (h) are measured with error (e) such that $h_j = h_j^* e_j$ for $j = m, n, l$, where h^* is the actual hours, and e_j is independent of h_j^*. It is easy to show that the observed covariance between hourly wage and hours of work is smaller than the actual covariance.

$$\begin{aligned} \text{Cov}(\ln w, \ln h_m) &= \text{Cov}(\ln w^*, \ln h_m^*) - \text{Var}(\ln e_m) \\ &\leq \text{Cov}(\ln w^*, \ln h_m^*), \end{aligned} \tag{14}$$

where w^* is the hourly wage calculated from the actual hours of work. The size of the bias increases with the variance of measurement error.

Because of the time constraint, the sum of the measurement errors must be zero, i.e., $e_m + e_n + e_l = 0$. Consequently, survey respondents who overstate their hours of work should understate their hours of home production or leisure so that the total hours equal 24 per day. The measurement errors e_m, e_n, and e_l should be, thus, non-positively correlated with each other. After simple algebra, the observed covariance between hourly wage and hours of home production (or leisure) can be shown to be smaller than the actual covariance by the covariance between measurement errors.

$$\begin{aligned} \text{Cov}(\ln w, \ln h_n) &= \text{Cov}(\ln w^*, \ln h_n^*) - \text{Cov}(\ln e_m, \ln e_n) \\ &\geq \text{Cov}(\ln w^*, \ln h_n^*). \end{aligned} \tag{15}$$

Therefore, the measurement error induces the wage coefficient α_L in the labor supply model to be biased downward but the wage coefficient α_l in the home production model to be biased upward. When this problem is ignored, the intertemporal substitution parameter obtained from the home production model will be large relative to the one obtained from the labor supply model.

3.3 Weak Instrument Problem

The elasticity of intertemporal substitution is known to be imprecisely estimated in many studies, and this tendency is prominent for studies that employ the first-difference approach. The weak instrument problem may underlie small and imprecise estimates of labor supply elasticity because first differencing exacerbates the division bias and weakens the correlation between hourly wage and instruments. Lee (2001) indeed demonstrates a substantial downward finite-sample bias of the two-stage least squares (2SLS). The first-difference approach is, thus, avoided here by parametrically specifying the fixed effects. Nonetheless, given that Staiger and Stock (1997) suggest instruments are weak if the first-stage F statistic does not exceed 10 for the case of a single endogenous regressor, instruments may still be deemed weak conditional on an extensive set of controls.

Some alternatives, known as the k-class estimators, improve on 2SLS when instruments are weak. The Fuller (1977) estimator is adopted among the alternative estimators in light of the results of Hahn, Hausman, and Kuersteiner (2004). Consider the linear regression model in which h is the $N \times 1$ vector of the dependent variable; X is the $N \times K$ matrix of the regressors; Z is the $N \times J$ matrix of instruments; N is the sample size; K is the number of parameters; and $J\,(> K)$ is the number of exogenous variables. The Fuller estimator is a modification of the limited information maximum likelihood estimator that is of the form

$$\frac{X'Ph - (\phi - c/\,(N-K))\,X'Mh}{X'PX - (\phi - c/\,(N-K))\,X'MX}, \tag{16}$$

where ϕ is the smallest eigenvalue of the matrix $W'PW\,(W'MW)^{-1}$ for $W \equiv [y, X]$, c is a positive constant, $P \equiv Z\,(Z'Z)^{-1}\,Z'$, and $M \equiv I - P$. The constant c is set to one because the Fuller estimator is then best unbiased to second order (Rothenberg, 1983). For the pre-test of weak instruments, the robust Kleibergen and Paap (2006) rank LM statistic is used because there are multiple endogenous regressors in the second specification for equation (13), where fertility as well as the hourly wage are treated as endogenous, and the errors are presumably heteroscedastic and correlated over time for a given individual.

Confidence sets can be obtained by inverting the acceptance regions of the Moreira (2003) conditional likelihood ratio test. This test is fully robust to weak instruments and does not require pre-test to detect weak instruments. The first specification is used for the fully robust inference because the test is applicable only for the case of a single endogenous regressor.

3.4 Missing Data Problem

Wages are observed only for the subpopulation of married women who are employed. If there is a systematic difference in unobserved characteristics between employed and non-employed individuals, the sample selection bias occurs by neglecting the decision to participate in the labor market. The missing data problem can be solved by incorporating the inverse Mills ratio as an additional regressor (Heckman, 1979). Let p denote an indicator variable for whether the woman is employed or a housewife. The participation decision can be described by:

$$p = x_p \xi + \epsilon_p, \tag{17}$$

where x_p is a vector of observed characteristics that affect the reservation wage, including the variables that represent preference shifters, family background characteristics, and fixed costs; and ϵ_p is a normally distributed error term. More specifically, the regressors x_p include age; years of own, husband's, father's and mother's education; number of siblings; maternal age at birth; the regional unemployment rate; and regional and year dummies. The regional unemployment rate, the key excluded instrument, is strongly significant with a *p*-value of zero. Co-residence with one's parents can affect labor market participation. Although the decision to live with parents is endogenous and co-residence should not be included as an exogenous regressor, such an effect can be captured by age, age difference with mother, and number of siblings.

The generated regressor bias can arise when estimation proceeds in multiple steps, and the errors in equation (13) may be heteroscedastic and correlated over time for a given individual. The standard errors are, thus, clustered at the individual level and computed using a block bootstrap technique.

4 Data Description and Preliminary Analysis

4.1 Data Summary

The analysis uses data from the Japanese Panel Survey of Consumers (JPSC) from 1994 to 2004. The survey respondents are women who were born between 1959 and 1979. The sample comprises 3,409 observations from 891 employed married women and 5,657 observations from 1,278 housewives, after excluding observations with missing values or clearly inconsistent responses regarding employment status, hours of work, and earnings.

The JPSC collects information about time use for weekdays and weekends and the number of holidays in a typical week. There are six categories of time use: (a) work, (b) commute, (c) study, (d) housework and child care, (e) hobby, recreation, and entertainment, (f) anything other than the above, including sleep, meals, bathing, and personal care. These categories are aggregated to market work, home production, and leisure corresponding to the time constraint in the theoretical model. Specifically, work includes categories (a), (b), and (c); home production is (d); and leisure includes both (e) active leisure and (f) passive leisure. Commute and study are classified as work because they are considered work-related activities, and commuting allowances are commonly paid as part of salaries and benefits in Japan. Whether the two categories are included in market work or not is, however, not critical for the analysis because commute and study, respectively, account for only 2.1% and 0.8% of total hours for employed married women.

Table 1 summarizes the means and standard deviations of employment status and time use. Of employed married women, 41% work full-time and 59% work part-time. Home production accounts for 21.2% of total hours, while market work and leisure account for 23.7% and 55.1%, respectively. The standard deviation of home production is greater than that of market work by 22.7% and approximately equals that of leisure. These facts motivate the analysis of home production. Figure 1 illustrates the distributions of market work, home production, and leisure, respectively. The hours of market work, home production, and leisure are all continuously distributed, which is consistent with the theoretical model in which the decision on hours is continuous. The reasons for such continuous variation are probably that many married women work part-time and that the time-use data are constructed from detailed questions about time use for weekdays and weekends and the number of holidays. Figure 2 illustrates changes in hours over the life cycle for employed married women. The data are not plotted by cohort because the shape of each curve is similar between the 1960s cohorts and the 1970s cohorts. A dip in female employment rate in the middle 30s is a well-known fact,[2] but the hours of work are found to rise and fall in a similar fashion.

When the hourly wage is calculated from detailed information about time use, the measure of hourly wage should be more accurate than a typical measure of hourly wage calculated from

[2] There is considerable cross-country diversity of changes in employment rate over the life cycle. Australia and Korea have a relatively similar shape to Japan (OECD, 2002).

retrospective information about annual hours of work, as emphasized by Juster and Stafford (1991). The quality of wage data is important in practice and may be an advantage of the study.[3]

Table 1 compares employed married women and housewives in terms of variables used in the analysis. There is no significant difference in educational background and family background between the two groups, but housewives tend to have young children relative to employed married women.

4.2 Disaggregate Analysis

Juster and Stafford (1991) presented the average pattern of time use in Japan and the United States in 1985 separately for males and females. When hours per week are categorized into market work, housework, leisure, and personal care, the mean hours of housework are remarkably different between the two countries for males. Japanese men spent only 3.5 hours on housework in a week, whereas American men did 13.8 hours. Instead, Japanese men spent more time on market work and personal care than American men. However, there was no significant difference between the two countries for females except for the breakdown of leisure activities.

Disaggregate analysis is conducted to further examine the comparability of Japanese household behavior. While few studies estimate the intertemporal household production model, many studies exist that conduct the cross-sectional regression of disaggregated hours on the hourly wage and unearned income. For this purpose, the following specification is chosen in the way that maintains the economic interpretation of the key parameter and that is comparable to cross-sectional regressions conducted by Gronau (1977), Biddle and Hamermesh (1990), Kimmel and Connelly (2007) and others.

$$h_j = \beta_j \ln w + Q\Psi_j + \epsilon_j \qquad \text{for} \quad j = m, n, l, \tag{18}$$

where Q is a vector of controls including unearned income, comprising husband's income, property income, and social security benefits; number of children under the age of 7; number of children aged 7 to 17; age; age squared; regional dummies; year dummies; and the inverse Mills ratio; and ϵ

[3] Rupert, Rogerson, and Wright (2000) use time-use data from the American Time Use Survey, but the wage variable used in their analysis is constructed at the cohort level from the Current Population Survey because of the poor quality of wage information in the American Time Use Survey.

is the error term. Age squared is included for this specification to be more interpretable compared to the Frisch demand function (13). Assuming that the parameters in the life-cycle income path (7c) are constant across education groups, property income can be cancelled out by second-order age polynomials. The price of child care is assumed to be constant within a region for a given year. The hourly wage and unearned income are treated as endogenous, and years of own and husband's education and husband's age are used as instruments. These instruments account for shifts in the wage and income profiles across households. The wage elasticity β_l / h_l can be interpreted as the response of leisure demand to a parallel shift in the wage profile, which is expected to be smaller in absolute value than the response of leisure demand to evolutionary movement along the life-cycle wage profile, because parametric shifts in the life-cycle profile induce a wealth effect (MaCurdy, 1981, 1985). The regressors in the participation equation are number of children under the age of 7, its square, its cubic; number of children aged 7 to 15, and its square; age; age squared; the regional unemployment ratel; regional dummies; and year dummies.

Some other related studies, such as Graham and Green (1984); Kooreman and Kapteyn (1987); Solberg and Wong (1992); Yamada, Yamada, and Kang (1999); and Kalenkoski, Ribar, and Stratton (2009), analyze the family model of time allocation in which the spousal wage rate is separately included as an additional regressor. Their analyses are, however, not inconsistent with the estimating equations (18) if husband's labor supply is exogenously given. Most married men in the JPSC sample indeed work full-time, and their labor supply is not sensitive to wage changes (Yamada, 2008).

Tables 2 presents the results of disaggregate analysis. A system of equations (18) is estimated by equation-by-equation 2SLS because instruments are strongly correlated with endogenous regressors and orthogonality conditions imposed may not be equally valid across equations. The time constraint restricts the sum of coefficients on the same regressor over three equations to be zero, but the results remain unchanged when the system of equations is jointly estimated by the generalized method of moments. The results suggest that higher wages increase market work but decrease home production and leisure, while higher unearned income decreases income but increases home production and leisure. The sign and significance of the estimated wage and income effects are fairly consistent with empirical findings in other countries. Children have a negative but insignificant effect on market work but a positive (negative) and highly significant effect on home production (leisure). The selection bias cannot be detected in market work but is present in home production and leisure. The estimated coefficient on the inverse Mills ratio suggests that those who tend to participate in the labor market are more likely to spend more time on home production and less time on leisure. The Hansen (1982) J statistic indicates that the orthogonality conditions used for estimation are valid for leisure but not for market work and home production. If the instruments are positively (negatively) correlated with the error term in the equation for market work (home production), the wage effect on market work and home production would be overestimated. Overall, the results obtained from the preliminary analysis are largely consistent with those found in previous studies.

There may be a question about whether full-time employees and part-time employees respond differently to wage and income changes. Yamada, Yamada, and Chaloupka (1987) argue that the wage elasticities differ between Japanese married women working full-time and part-time. In response to this concern, equations (18) were estimated separately for full-time and part-time employees conditional on the inverse Mills ratio computed from the ordered probit model in which the dependent variable takes a value of two if working full-time, a value of one if working part-time, and a value of zero if a housewife. Industry dummies that account for demand-side conditions were used as instruments instead of years of education to maintain a strong correlation between hourly wage and instruments. When estimating the ordered response selection model with endogenous regressors, the wage effect on market work is positive but much smaller and statistically insignificant both for full-time employees and part-time employees. The results are not surprising, considering that a change in job status is an important source of variation in hours, and are not inconsistent with those of Nakamura and Nakamura (1983) who conducted a similar analysis in Canada and the United States and obtained small and negative labor supply elasticities. Therefore, this study focuses on the theoretically relevant parameter that allows for substitution resulting from a change in hours owing to a change in job status.

5 Empirical Results

The objective of this study is to provide the estimates of intertemporal substitution elasticity in the home production model. Table 3 presents the main results regarding the Fuller estimates of α_l in equation (5) along with those of α_L in equation (12) for comparison. A 10% increase in the hourly wage results in a decrease of 4.45 hours of home production and leisure and 3.05 hours of leisure per week. After controlling for the number of young children, a 10% increase in the hourly wage results in a decrease of 3.73 hours of home production and leisure and 2.85 hours of leisure per week. As theory predicts, the response of leisure demand to evolutionary movement along the wage profile reported in columns 3 and 4 of Table 3 is found to be greater than the response to parametric shifts in the wage profile seen in column 3 of Table 2. The implied Frisch elasticities are quantitatively similar between the labor supply model and the home production model, and they are both moderate. The selection bias is present in column 3 when estimating the home production model but disappears in column 4 after controlling for fertility. The Kleinbergen-Paap rank LM statistic is moderately high, and the Hansen *J* statistic indicates that the instruments used are valid.

To clarify the interpretation of the results regarding the magnitude of intertemporal substitution elasticities in the two models, consider the equation for home production that is specified the same way as equation (13):

$$h_n = \alpha_n \ln w + X\Gamma_n + \epsilon_n. \tag{19}$$

Some simple algebra shows that the estimate of the preference parameter in the labor supply model can be decomposed into the estimate of the preference parameter in the home production model and the estimate of wage coefficient in equation (19), i.e., $\widehat{\alpha}_L = \widehat{\alpha}_l + \widehat{\alpha}_n$. The decomposition implies that

$$|\widehat{\alpha}_L| \geq |\widehat{\alpha}_l| \qquad \text{if } \widehat{\alpha}_n < 0, \tag{20a}$$

$$|\widehat{\alpha}_L| < |\widehat{\alpha}_l| \qquad \text{if } \widehat{\alpha}_n \geq 0. \tag{20b}$$

The estimates of α_L and α_l are compared in absolute value for ease of interpretation, because they are both negative. The inequalities show that the sign of $\widehat{\alpha}_n$ determines which parameter is greater.

The similar magnitude of the estimated wage coefficients between labor supply model and home production model implies that time engaged in home production does not significantly vary in response to evolutionary wage changes. In light of the disaggregate analysis indicating that $\widehat{\alpha}_n$ is negative, it seems plausible that the intertemporal substitution elasticity is not greater in the home production model than in the labor supply model.

The 95% confidence region of the Frisch elasticity, based on the conditional likelihood ratio test in Moreira (2003), is [0.28, 1.12] in the labor supply model and [0.23, 0.76] in the home production model. Both intervals are relatively tight and fall within the range of typical estimates of female labor supply elasticities in the literature. This method indicates that the upper bound of the Frisch elasticity obtained from the labor supply model is 36 percentage points greater than that obtained from the home production model.

6 Conclusion

This paper has studied a life-cycle model of home production to examine how married women change their allocation of time in response to evolutionary movements along the life-cycle wage profile in Japan. In doing so, several econometric issues have been dealt with: preference heterogeneity, measurement error, weak instruments, and missing data. The estimates of intertemporal substitution elasticity obtained from the home production model were found to be moderate and similar to those obtained from the standard labor supply model.

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Table 1: Summary Statistics

Panel A: Employed Married Women			
Variables	Mean (S.D.)	Variables	Mean (S.D.)
Weekly hours of		Number of children	
Market work	39.8 (14.1)	Under the age of 7	0.58 (0.77)
Home production	35.6 (17.3)	Aged 7 to 17	0.98 (0.98)
Leisure	92.6 (17.4)	Years of schooling	
Hourly wage	0.93 (0.66)	Own	13.1 (1.52)
Unearned income per week	99.3 (49.1)	Husband	13.2 (2.25)
Age		Father	11.3 (2.30)
Own	34.3 (4.66)	Mother	10.8 (1.80)
Husband	37.0 (5.97)	Number of siblings	2.54 (0.96)
Mother	61.6 (6.44)		

Panel B: Housewives			
Variables	Mean (S.D.)	Variables	Mean (S.D.)
Age		Years of schooling	
Own	32.4 (4.27)	Own	13.1 (1.68)
Husband	35.3 (5.67)	Husband	13.6 (2.30)
Mother	59.8 (6.06)	Father	11.6 (2.29)
Number of children		Mother	11.2 (1.81)
Under the age of 7	1.13 (0.85)	Number of siblings	2.50 (0.96)
Aged 7 to 17	0.61 (0.87)		

Note: Wages and income are measured in thousands of yen.

Table 2: Disaggregate Analysis of Time Allocation

	(1) Market Work	(2) Home Production	(3) Leisure
log hourly wages	18.65	-6.19	-12.46
	(4.26)	(4.63)	(4.05)
Unearned income	-0.74	0.45	0.29
	(0.48)	(0.56)	(0.55)
No. of children aged 0–6	-1.56	7.25	-5.69
	(1.24)	(1.77)	(1.69)
No. of children aged 7–17	-0.97	4.23	-3.27
	(0.70)	(0.75)	(0.77)
Inverse Mills ratio	1.32	9.37	-10.68
	(3.53)	(4.82)	(4.77)
Wage elasticity	0.47	-0.17	-0.13
	(0.11)	(0.13)	(0.04)
Income elasticity	-0.18	0.13	0.03
	(0.12)	(0.16)	(0.06)
Hansen *J* statistic	4.89	5.99	0.14
	{0.03}	{0.01}	{0.71}
Kleinbergen-Paap		32.00	
rank LM statistic		{0.00}	

Notes: Standard errors in parentheses are clustered at the individual level and computed by block bootstrap. Other covariates are a constant, age, age squared, regional dummies, and year dummies. The hourly wage and unearned income are treated as endogenous. Excluded instruments used are own and husband's education and husband's age. The elasticities are evaluated at the sample means.

Table 3: Intertemporal Time Allocation Models

	(1)	(2)	(3)	(4)
	Labor Supply Model		Home Production Model	
	$h_n + h_l$		h_l	
log hourly wages	-44.48	-37.31	-30.50	-28.54
	(17.52)	(10.53)	(12.99)	(11.18)
No. of children aged 0–6		4.88		-7.12
		(2.97)		(2.93)
No. of children aged 7–17		4.48		-2.21
		(3.15)		(3.03)
inverse Mills ratio	1.53	12.92	-23.28	5.57
	(2.48)	(10.39)	(2.71)	(9.04)
Frisch elasticity	-0.35	-0.29	-0.33	-0.31
	(0.14)	(0.08)	(0.14)	(0.12)
Hansen *J* statistic	3.96	2.64	1.19	1.58
	{0.27}	{0.45}	{0.76}	{0.12}
Kleinbergen-Paap	8.08	10.14	8.08	10.14
rank LM statistic	{0.09}	{0.04}	{0.09}	{0.04}

Notes: Standard errors in parentheses are clustered at the individual level and computed by block bootstrap, and *p*-values are in curly brackets. Other covariates are a constant, education, age, father's education, mother's education, number of siblings, maternal age at birth, regional dummies, and year dummies. The hourly wage is treated as endogenous in all columns, and the number of children is treated as endogenous in columns 2 and 4. Excluded instruments used include the interaction terms between age squared and education dummies in all columns, and additionally include age cubic and age quartic in columns 2 and 4. The elasticities are evaluated at the sample means.

Figure 1: Hours Distribution

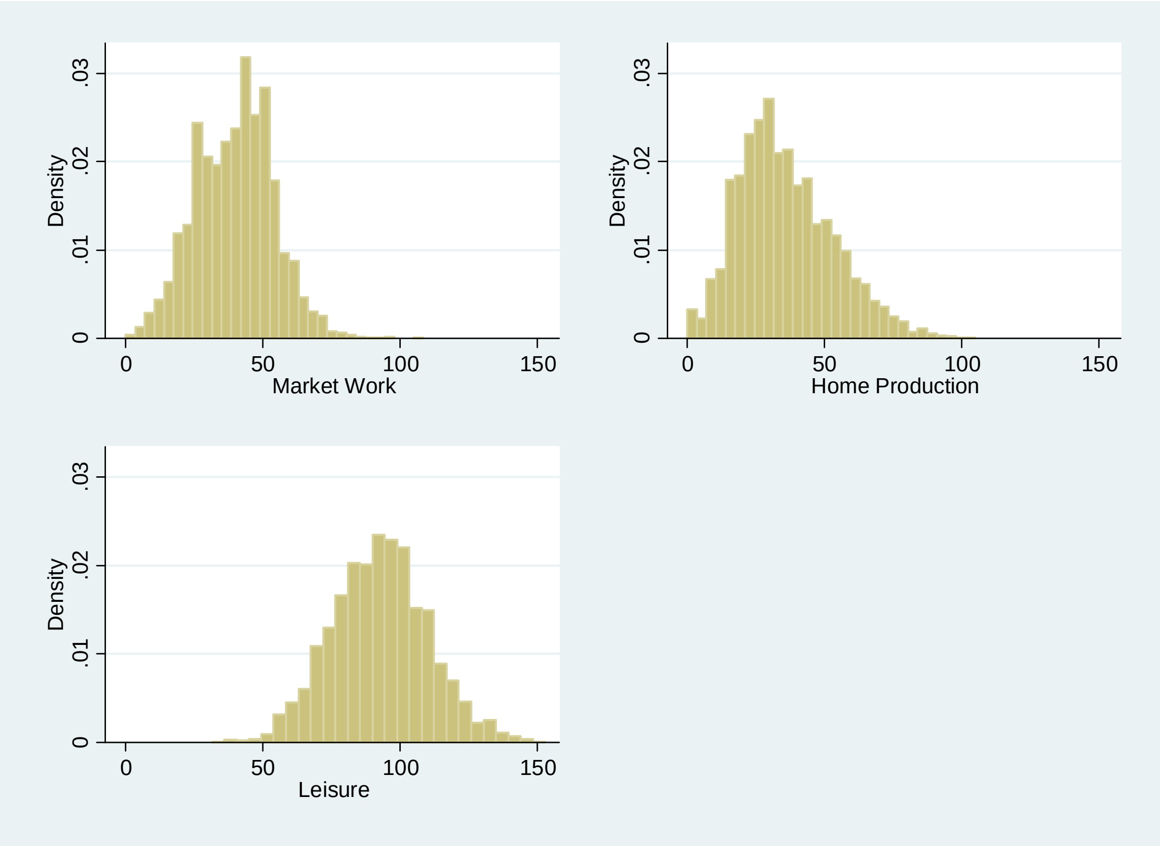

Figure 2: Market Work, Home Production, Leisure, and Wages over the Life Cycle